A dual-polarized microstrip subarray antenna for an inflatable L-band synthetic aperture radar

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Introduction

Inflatable technology has been identified as a potential solution to the problem of achieving small mass, high packaging efficiency, and reliable deployment for future NASA spaceborne synthetic aperture radar (SAR) antennas. Presently, there exists a requirement for a dual-polarized L-band SAR antenna with an aperture size of 10m x 3m, a center frequency of 1.25GHz, a bandwidth of 80MHz, electronic beam scanning, and a mass of less than 100kg. The work presented below is part of the ongoing effort to develop such an inflatable antenna array [1].

Antenna Description

The final 10m x 3m array will have 14 rows with 48 elements each. The 48 elements per row will be further subdivided into eight six-element subarrays. The subarray is shown in Fig. 1 and was designed using commercial software. The final inflatable antenna will use free-space as the dielectric medium. However, to facilitate construction and testing here on earth, the subarray can be made with a 12.7mm Nomex honeycomb core sandwiched between two 51μm Kapton sheets, each with a thin copper skin. The microstrip circuit is etched onto one of the Kapton sheets while the other sheet serves as a ground plane.

The subarray has two inputs: one for vertical polarization (V-pol) and one for horizontal polarization (H-pol). The V-pol array uses a one-port series feed with each of the three elements on either side of the input probe connected together with a one-wavelength long transmission line, which produces a broadside beam in V-pol. The H-pol array uses a two-port series feed to connect the three elements on either side of the feed probe together. The lengths of these thin, connecting transmission lines were also adjusted to produce a broadside beam in H-pol.

The V-pol E-plane patch dimension is intentionally tuned off resonance. This off-tune impedance is then transformed through a short transmission line (38mm) so that a 300Ω resistance is presented to the main bus at the center frequency of 1.25GHz. This short transformer, which is shorter than a quarter-wavelength (approx. 59mm), accomplishes two things: 1) it presents a high input impedance to the bus, which is desirable since the patch impedances add in parallel; and 2) it gives a smaller overall size in the V-pol direction than a quarter-wave transformer would. The H-pol E-plane dimension is chosen to give a resonant condition at 1.25GHz. The patch shape is rectangular due to the separate tuning of each polarization.

A symmetric, dual-offset feed to the three H-pol elements on the right side of the probe (see Fig. 1) gives the 180° phase delay required to produce a broadside beam. A wider, low-impedance line was desired here to more closely match the input impedance of the three-element group. However, this was impractical because limited space made it difficult to route a wide line for a 180° phase delay. In a dual-offset configuration, the characteristic impedance in each arm is set at twice the desired impedance. The parallel combination of the two transmission lines is then equivalent schematically to a single line with the desired characteristic impedance. The resulting thinner lines are much easier to route. The symmetry of the dual-offset configuration will also help reduce cross-polarized radiation in the H-pol patterns.

Since a fairly thick substrate is used, a significant undesirable series inductance is introduced at the feed probe. Previous solutions to this problem have included etching an annular ring around the feed probe [2] and using a series gap capacitor underneath the microstrip layer [3]. The approach used here is similar to the one in [3] except that a capacitive "hat" is used on top of the microstrip layer instead of below it (see Fig. 1). This configuration permits much simpler fabrication and tuning.

RF Test Results

The measured return loss and input impedance plots for both polarizations are given in Fig. 2. The 10dB-bandwidths were about 14% for V-pol and greater than 13% for H-pol, easily meeting the requirement of 6.4% (80MHz). The calculated and measured array plane patterns for both polarizations are shown in Figure 3 and agree very well. The measured gains at 1.25GHz were 16.6dB for V-pol and 16.0dB for H-pol. The calculated gains were 16.2dB for V-pol and 15.8dB for H-pol. Patterns and gain were measured at the band edges and the results were relatively good. In both H- and V-pols, cross-polarization levels at 1.25GHz were better than 20dB down from the corresponding co-pol maxima for angles less than 3° off the main beam peak. Overall, the subarray performed very well. One improvement, though, would be the reduction of the sidelobes in the V-pol pattern.

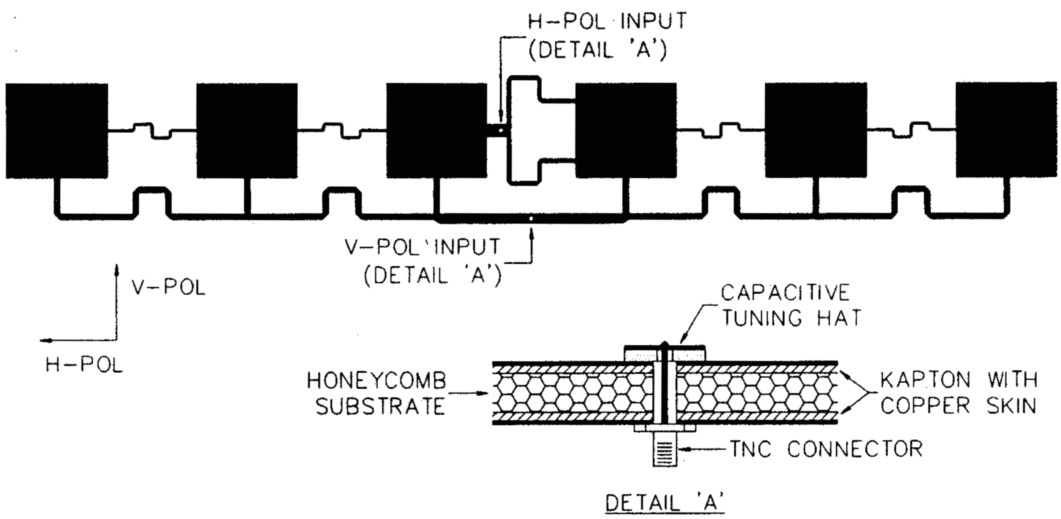

Figure 1. A six-element dual-polarized subarray for inflatable SAR applications
Overall dimensions: 110cm x 16cm x 1.3cm (approx.)

Acknowledgement

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References

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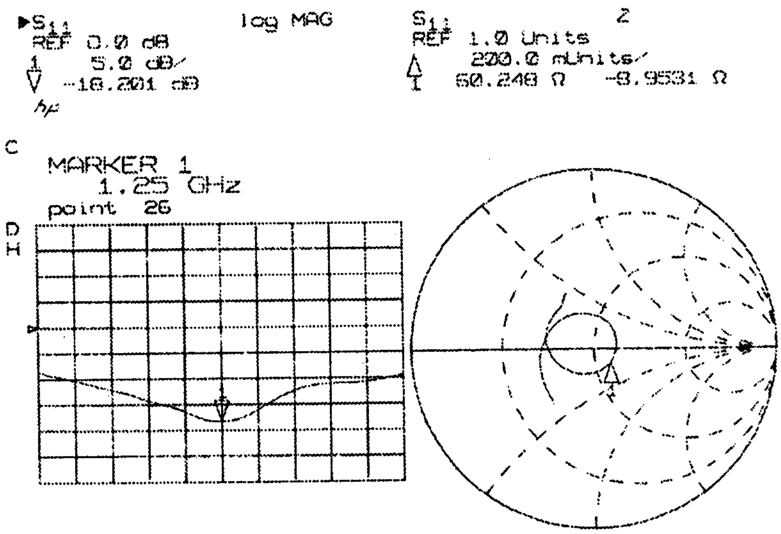
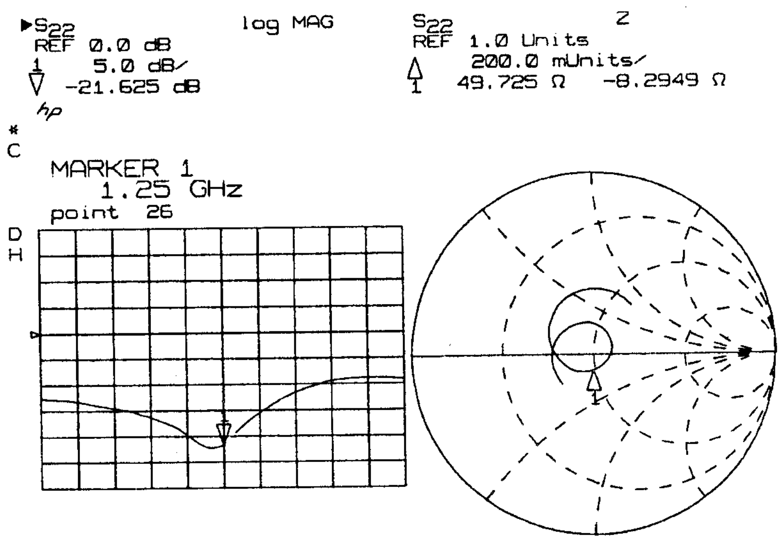
2. M. J. Alexander, "Capacitive matching of microstrip antennas", IEE Proceedings, Vol. 136, Pt. H, No. 2, April 1989, pp. 172-174.

3. B. Robert, T. Razban, and A. Papiernik, "Capacitors provide input matching of microstrip antennas", Microwaves and RF, July 1994, pp. 103-106.

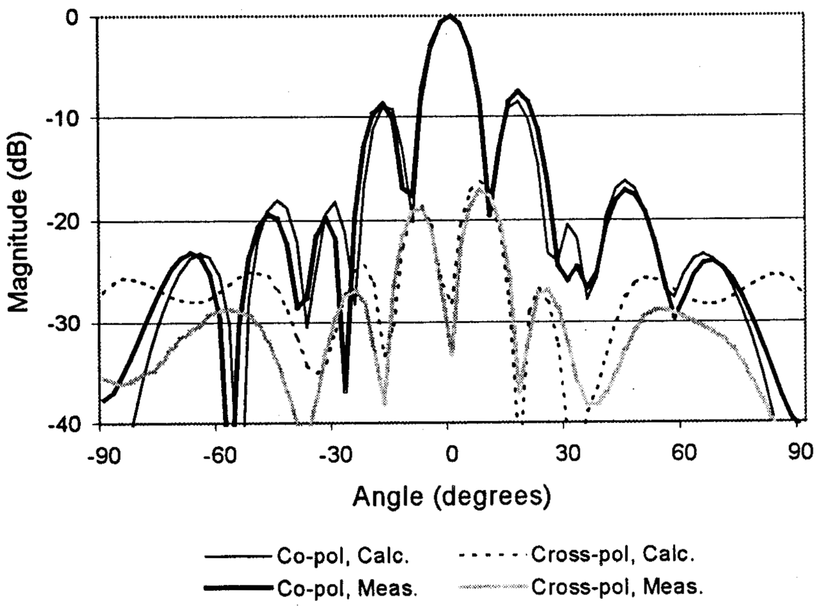


(a)



(b)

Figure 2. Measured return loss and input impedance.
Start: 1.15GHz, Stop: 1.35GHz
(a) V-pol, (b) H-pol.



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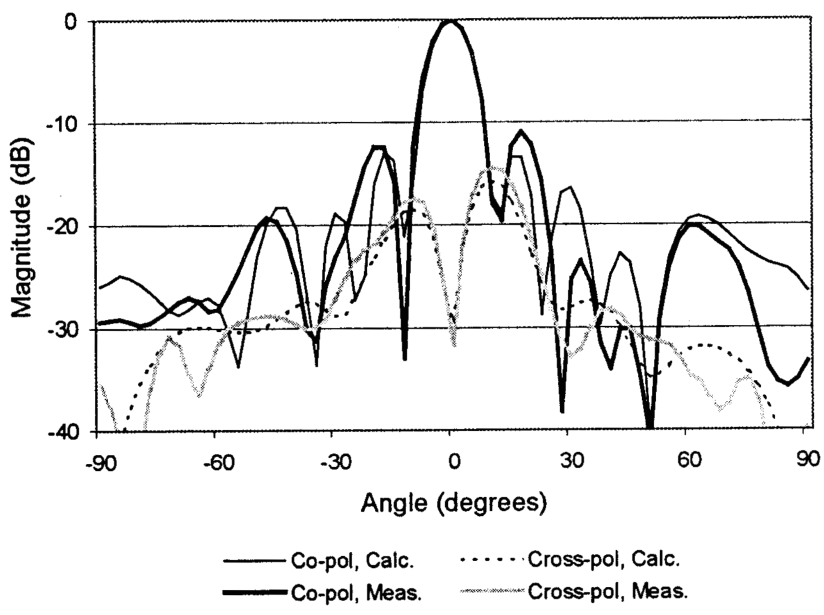

(b)

Figure 3. Measured and calculated patterns at 1.25GHz.
(a) V-pol, H-plane. (b) H-pol, E-plane.